

## FUNDAMENTAL PLASMA PARAMETERS

All quantities are in Gaussian cgs units except temperature ( $T$ ,  $T_e$ ,  $T_i$ ) expressed in eV and ion mass ( $m_i$ ) expressed in units of the proton mass,  $\mu = m_i/m_p$ ;  $Z$  is charge state;  $k$  is Boltzmann's constant;  $K$  is wavelength;  $\gamma$  is the adiabatic index;  $\ln \Lambda$  is the Coulomb logarithm.

### Frequencies

electron gyrofrequency	$f_{ce} = \omega_{ce}/2\pi = 2.80 \times 10^6 B \text{ Hz}$
	$\omega_{ce} = eB/m_e c = 1.76 \times 10^7 B \text{ rad/sec}$
ion gyrofrequency	$f_{ci} = \omega_{ci}/2\pi = 1.52 \times 10^3 Z \mu^{-1} B \text{ Hz}$
	$\omega_{ci} = ZeB/m_i c = 9.58 \times 10^3 Z \mu^{-1} B \text{ rad/sec}$
electron plasma frequency	$f_{pe} = \omega_{pe}/2\pi = 8.98 \times 10^3 n_e^{1/2} \text{ Hz}$
	$\omega_{pe} = (4\pi n_e e^2/m_e)^{1/2}$
	$= 5.64 \times 10^4 n_e^{1/2} \text{ rad/sec}$
ion plasma frequency	$f_{pi} = \omega_{pi}/2\pi$
	$= 2.10 \times 10^2 Z \mu^{-1/2} n_i^{1/2} \text{ Hz}$
	$\omega_{pi} = (4\pi n_i Z^2 e^2/m_i)^{1/2}$
	$= 1.32 \times 10^3 Z \mu^{-1/2} n_i^{1/2} \text{ rad/sec}$
electron trapping rate	$\nu_{Te} = (eKE/m_e)^{1/2}$
	$= 7.26 \times 10^8 K^{1/2} E^{1/2} \text{ sec}^{-1}$
ion trapping rate	$\nu_{Ti} = (ZeKE/m_i)^{1/2}$
	$= 1.69 \times 10^7 Z^{1/2} K^{1/2} E^{1/2} \mu^{-1/2} \text{ sec}^{-1}$
electron collision rate	$\nu_e = 2.91 \times 10^{-6} n_e \ln \Lambda T_e^{-3/2} \text{ sec}^{-1}$
ion collision rate	$\nu_i = 4.80 \times 10^{-8} Z^4 \mu^{-1/2} n_i \ln \Lambda T_i^{-3/2} \text{ sec}^{-1}$

### Lengths

electron deBroglie length	$\lambda = \hbar/(m_e k T_e)^{1/2} = 2.76 \times 10^{-8} T_e^{-1/2} \text{ cm}$
classical distance of minimum approach	$e^2/kT = 1.44 \times 10^{-7} T^{-1} \text{ cm}$
electron gyroradius	$r_e = v_{Te}/\omega_{ce} = 2.38 T_e^{1/2} B^{-1} \text{ cm}$
ion gyroradius	$r_i = v_{Ti}/\omega_{ci}$
	$= 1.02 \times 10^2 \mu^{1/2} Z^{-1} T_i^{1/2} B^{-1} \text{ cm}$
plasma skin depth	$c/\omega_{pe} = 5.31 \times 10^5 n_e^{-1/2} \text{ cm}$
Debye length	$\lambda_D = (kT/4\pi ne^2)^{1/2}$
	$= 7.43 \times 10^2 T^{1/2} n^{-1/2} \text{ cm}$

## Velocities

electron thermal velocity	$v_{Te} = (kT_e/m_e)^{1/2}$ $= 4.19 \times 10^7 T_e^{1/2} \text{ cm/sec}$
ion thermal velocity	$v_{Ti} = (kT_i/m_i)^{1/2}$ $= 9.79 \times 10^5 \mu^{-1/2} T_i^{1/2} \text{ cm/sec}$
ion sound velocity	$C_s = (\gamma Z k T_e / m_i)^{1/2}$ $= 9.79 \times 10^5 (\gamma Z T_e / \mu)^{1/2} \text{ cm/sec}$
Alfvén velocity	$v_A = B / (4\pi n_i m_i)^{1/2}$ $= 2.18 \times 10^{11} \mu^{-1/2} n_i^{-1/2} B \text{ cm/sec}$

## Dimensionless

(electron/proton mass ratio) <sup>1/2</sup>	$(m_e/m_p)^{1/2} = 2.33 \times 10^{-2} = 1/42.9$
number of particles in Debye sphere	$(4\pi/3)n\lambda_D^3 = 1.72 \times 10^9 T^{3/2} n^{-1/2}$
Alfvén velocity/speed of light	$v_A/c = 7.28 \mu^{-1/2} n_i^{-1/2} B$
electron plasma/gyrofrequency ratio	$\omega_{pe}/\omega_{ce} = 3.21 \times 10^{-3} n_e^{1/2} B^{-1}$
ion plasma/gyrofrequency ratio	$\omega_{pi}/\omega_{ci} = 0.137 \mu^{1/2} n_i^{1/2} B^{-1}$
thermal/magnetic energy ratio	$\beta = 8\pi nkT/B^2 = 4.03 \times 10^{-11} nTB^{-2}$
magnetic/ion rest energy ratio	$B^2/8\pi n_i m_i c^2 = 26.5 \mu^{-1} n_i^{-1} B^2$

## Miscellaneous

Bohm diffusion coefficient	$D_B = (ckT/16eB)$ $= 6.25 \times 10^6 TB^{-1} \text{ cm}^2/\text{sec}$
transverse Spitzer resistivity	$\eta_\perp = 1.15 \times 10^{-14} Z \ln \Lambda T^{-3/2} \text{ sec}$ $= 1.03 \times 10^{-2} Z \ln \Lambda T^{-3/2} \Omega \text{ cm}$

The anomalous collision rate due to low-frequency ion-sound turbulence is

$$\nu^* \approx \omega_{pe} \tilde{W} / kT = 5.64 \times 10^4 n_e^{1/2} \tilde{W} / kT \text{ sec}^{-1},$$

where  $\tilde{W}$  is the total energy of waves with  $\omega/K < v_{Ti}$ .

Magnetic pressure is given by

$$P_{\text{mag}} = B^2 / 8\pi = 3.98 \times 10^6 B^2 \text{ dynes/cm}^2 = 3.93 (B/B_0)^2 \text{ atm},$$

where  $B_0 = 10 \text{ kG} = 1 \text{ T}$ .

Detonation energy of 1 kiloton of high explosive is

$$W_{\text{kT}} = 10^{12} \text{ cal} = 4.2 \times 10^{19} \text{ erg.}$$